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EVALUATION OF BIOPESTICIDES DERIVED FROM GARLIC (ALLIUM SATIVUM) AND HING (ASAFOETIDA) FOR CONTROLLING WHITEFLIES IN OKRA CROPS AND APHIDS IN POTATO CROPS

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Abstract

This study aimed to assess the effectiveness of biopesticides in managing whiteflies (Bemisia tabasi) in okra crops and aphids in potato crops. Specifically, biopesticides derived from garlic (Allium Sativum) and asafoetida, in conjunction with an adjuvant developed by the Nuclear Institute for Food and Agriculture (NIFA) in Peshawar, were investigated. These biopesticides represent a promising alternative to conventional synthetic insecticides, as they are highly effective and environmentally friendly. The research was conducted in a field at NIFA during the year 2018.

Methods: Three biopesticides were examined, including extracts from A. Sativum and asafoetida, as well as a combined formulation of both. Whiteflies were targeted in okra crops, while aphids were targeted in potato crops. The efficacy of the biopesticides was assessed based on pest control and crop health parameters.

Results: The study revealed that the combined formulation of A. Sativum and asafoetida exhibited the highest efficacy in controlling whiteflies in okra crops and aphids in potato crops. This formulation demonstrated superior pest control performance compared to individual A. Sativum or asafoetida extracts.

Conclusion: Biopesticides derived from the combination of A. Sativum and asafoetida hold significant potential for managing whiteflies in okra crops and aphids in potato crops. Further research should be conducted to identify and evaluate additional active compounds that can serve as potential candidates for biopesticide development. This approach will help maintain the environmentally friendly nature of biopesticides, making them a preferable choice over synthetic alternatives for pest control in agricultural systems.

Keywords: Aphids, biopesticides, efficacy, okra, potato, whitefly

Introduction

Garlic (*Allium sativum*), a member of the Liliaceae family, contains several chemical compounds that exhibit antibacterial, anticancer, and antioxidant properties (Omar and Al-Wabel, 2010). It also possesses naturally occurring characteristics effective in managing pests, particularly fungicidal and insecticidal properties. This biological insecticide is commonly used in the agricultural industry due to its cost-effectiveness and non-toxic nature (Patterson, 2014). Because of its potent natural odor, garlic can act as a form of olfactory camouflage against insects by reducing the usual host-finding or feeding cues that these pests respond to (Perrin and Phillips, 1978). Ants, termites, aphids, beetles, whiteflies, caterpillars, borers, slugs, and armyworms are among the pests that can be effectively managed using garlic (Kaluwa and Kruger, 2012). Previous research has reported that garlic exhibits antimicrobial, bactericidal, fungicidal, acaricidal, and nematocidal characteristics, as well as properties that kill both insects and fungi (Lall et al., 2013). It also contains a variety of therapeutic phytoconstituents, including sulphide derivatives, terpenoids, phenols, minerals, and volatile oil.

Hing (*Ferula foetida*) has been shown to have beneficial effects on the body's healing process. It is also known to contain the constituent asafoetida, which has antidiabetic, intoxicant, anticancer, antimicrobial, and antibacterial effects, among others (Kareparamban et al., 2012). As Pakistan is still a developing nation, a large quantity of agrochemicals is utilized to reduce the number of pests that threaten crop production and to boost crop yields. However, there is currently an increased demand for methods that are natural, rational, safe, and environmentally friendly. People nowadays are exposed to significant risks. For this reason, it is of utmost significance to shift focus towards organic farming and the use of biopesticides for pest control in plant protection.

Materials and Methods

Experimental Design

Two separate experiments were conducted at NIFA's research facility. For proper statistical analysis, the experiments were laid out in a Completely Randomized Design (CRD). Three sets of replicates were kept for each factor, i.e., garlic, hing, garlic and hing bio compound biopesticide, and the control. Two distinct sections of land were allocated for the cultivation of okra and potatoes. The potato plot had dimensions of 35 feet in width and 80 feet in length, with a row-to-row spacing of 24 inches and a plant-to-plant distance of 12 inches. This setup was replicated for each treatment. Each okra plot measured 15 feet in width and 90 feet in length, with a row-to-row spacing of 18 inches and a plant-to-plant distance of 12 inches.

Preparation of Plant Extract

The dried material from each plant section was pulverized into a fine powder using a pestle and mortar. To prepare a 10% stock solution of each plant extract, 100 grams of powder were mixed with 400 mL of methanol. The mixture of grinds and methanol was shaken for three hours at a speed of 260 revolutions per minute in a small orbital shaker, then filtered using a Buchner funnel lined with Whatman No. 1 filter paper to remove any insoluble material. Subsequently, the methanol portion was isolated, and the solvent was evaporated. After filtration, the filtrate was combined with water in a conical flask to achieve a final volume of 1 liter. The mixture was vigorously stirred and left to stand for a full day before being strained through muslin fabric to remove any contaminants. The stock solution was then diluted to a 5% concentration of plant extracts for field application.

Formulation of Biopesticides

To prepare the garlic extract solution, mix 5% garlic extract with 5 mL of NIFA adjuvant per 10 L of water. For the hing extract solution, combine 5% hing extract with 5 mL of NIFA adjuvant per liter of water. Alternatively, for a combined solution, mix garlic extract at 3.5% concentration and hing extract at 1.5% concentration with NIFA adjuvant, adding 5 mL for every 10 L of water.

The adjuvant, developed by the institute NIFA, is an organosulfur chemical serving as an emulsifier, spreader, adhesive, and stabilizer. It has demonstrated stability over three years and can be diluted with water to augment pesticide effectiveness.

Application of Chemicals
Spraying was conducted at night using a knapsack sprayer to maximize chemical efficacy by ensuring complete coverage of the treated area.

Efficacy of Botanical Biopesticides
Spraying was performed using a knapsack sprayer to maximize chemical efficiency by achieving total coverage of the target area.

Insect Count
Reductions in whitefly and aphid populations were monitored 48 hours, 72 hours, and 1 week after treatments to assess the effectiveness of the biopesticides. Five plants were randomly selected across all plots. For each plant, five leaves were selected: two from the top, two from the center, and one from the bottom. The mean bug population for each plot was calculated by averaging the data collected before and after spraying.

Statistical Analysis
Basic statistical tests such as mean and standard deviation were conducted using SPSS for Windows software, along with more advanced tests like one-way analysis of variance and the Least Significant Differences (LSD) test. Statistically significant differences between the means of treatment and control plots were determined at the P=0.05 level.

Results
The effects of the various treatments, including extracts of garlic, hing, and a garlic+hing bio-compound, on decreasing whitefly infestation in okra crops and aphids on potato plants revealed significant variability in the findings. This variability could be attributed to differences in the timing of data recording, i.e., days after sowing.

In the control plots, which were not treated with any of the extracts, the number of whiteflies and aphids progressively increased. However, plants treated with the extracts showed variable and considerable reductions in both whitefly and aphid populations.

The invasive species first appeared during the first week, began spreading during the second and third weeks, and reached its peak levels between the fourth and eighth weeks. The results of the analysis of variance indicated a significant difference between the treatments ($p<0.05$).

Regarding the bio-pesticidal effect of garlic, hing, and garlic+hing bio-compound on whiteflies in okra, no statistically significant difference in treatment means was found using one-way ANOVA at the 0.05 α level. However, the bio-compound reduced the whitefly population by an average of 3.0 (range: 3-3.4) on day 22, followed by an average of 2.6 (range: 2.2-3.4) on day 23, and an average of 3.1 (range: 2.8-3.4) on day 28. Another two weeks later, on day 42, the whitefly population had risen to an average of 6.3, with a range of 5.0-8.0. The population on the 42nd day after the second spray was between 2.3 and 2.6, on the 44th day between 2.1 and 2.4, and on the 49th day between 2.8 and 2.9.

Garlic biopesticides had the second-highest impact against whiteflies. After the first spray of garlic bio-pesticide, the whitefly population was between 3 and 4 with an average of 3.2 on day 22, followed by an average of 3.1 with the range between 2.6 and 3.8 on day 23, and the range was between 2.8 and 3.4 on day 28. In the subsequent fortnight between sprays, the whitefly population rose from day 42 to day 44 by an average of 0.6. The population on the 43rd day after the second spray was estimated to be between 2.23 and 3.0 (with an average of 2.6), while on the 44th day it was estimated to be between 2.22 and 2.8 (with an average of 2.4), and on the 49th day it was estimated to be between 2.22 and 3.4 (with an average of 2.9).

The whitefly population after the first spray of Hing ranged from 3.2 to 3.8, with an average of 3.4 on day 22, from 3 to 3.4 with an average of 3.3 on day 23, and from 3 to 4 with an average of 3.5 on day 28. Afterward, the whitefly population rose from day 0 to day 42, with a range of 6.2 to 8.8, and an average of 6.5. According to the data, the population after the second spray varied between 2.6-3.0 with an average of 2.9 on day 43, between 2.3-2.0 with an average of 2.7 on day 44, and between 3.2-3.8 with an average of 3.5 on day 49.

Regarding the bio-pesticidal effect of garlic, hing, and garlic+hing bio-compound on aphids in potatoes, no statistically significant difference in treatment means was found using one-way ANOVA at $\alpha = 0.05$ level. The aphid population declined after the first spray with the bio-compound of garlic and hing, ranging from 2.0 to 2.4 with an average of 2.2 on day 22, from 1.6 to 2.4 with an average of 1.9 on day 23, and from 2.4 to 3.2 with an average of 2.7 on day 28. After the spraying stopped for two weeks, the aphid population spiked from 6.8 to 7.6 on day 42 with an average of 7.2. The population varied from 1.82 to 2.66 on day 43 after the second spray, 1.62 to 2.43 on day 44, and 2.73 to 2.7 on day 49.

On day 22 after the first spray of garlic extract, the aphid population was between 2.2 and 3 with an average of 2.7, between 1.6 and 2.4 with an average of 2.1 on day 23, and between 2.8 and 3.4 with an average of 3.1 on day 28. After spraying was stopped for two weeks, the aphid population rose from 7.2 to 7.8 on day 42 with an average of 7.6. From day 43 to day 49, the population after the second spray varied between 2.4 and 2.6 (with an average of 2.5 on day 43), 2.8 and 2.6 (with an average of 2.2 on day 44), and 2.4 and 3.2 (with an average of 2.7 on day 49).

The aphid population after the first spray of Hing biopesticide varied from 2.6 to 3.4, averaging 2.9 on day 22, it was between 2.2 and 3 averaging 2.6 on day 23, and between 3.0-3.6 averaging 3.3 on day 28. After the two-week spray interval, the aphid population grew from day 42 onwards, with counts ranging between 7.5 and 8.2 on average. The population on the 42nd day after the second spray fell between 2.2 and 3 with an average of 2.5, on 44th day between 2.2 and 2.6 with an average of 2.3, and on 49th day between 2.4 and 3.2 with an average of 2.9. **(Table 2)**.

Table-1.Biopesticidal effect of garlic and hing against whitefly on okra plants

Biopesticides	Day 22	Day 23	Day 28	Day 42*	Day 43	Day 44	Day 49
Garlic	3.2	3.2	2.8	7.2	2.6	2.2	3.2
	3	2.7	3.8	6.4	3.0	2.2	3.4
	3.4	2.6	3.6	7.2	2.2	2.8	2.2
Max	3.4	3.2	3.8	7.2	3.0	2.8	3.4
Min	3.0	2.6	2.8	6.4	2.2	2.2	2.2
Hing	3.2	3.0	3.2	6.8	3.0	2.8	3.8
	3.2	3.4	3.4	6.6	3.0	2.0	3.4
	3.8	3.4	4.0	6.2	2.6	3.2	3.2
Max	3.8	3.4	4.0	6.8	3.0	3.2	3.8
Min	3.2	3.0	3.2	6.2	2.6	2.0	3.2
Garlic+Hing	3.4	2.2	3.4	5.8	2.6	2.4	2.6
	3.0	3.4	2.8	6.4	2.4	1.8	2.8
	3.0	2.2	3.2	6.6	2.0	2.0	3.0
Max	3.4	3.4	3.4	6.6	2.6	2.4	3.0
Min	3.0	2.2	2.8	5.8	2.0	1.8	2.6

*There was a spray interval of two weeks from Day 28 to Day 42

Table 2.Bio-pesticidal effect of garlic and hing against aphid on potato plants

Biopesticides	Day 22	Day 23	Day 28	Day 42*	Day 43	Day 44	Day 49
Garlic	2.8	2.4	3.4	7.8	2.6	1.8	3.2
	3.0	2.2	2.8	7.8	2.4	2.6	2.4
	2.2	1.6	3.2	7.2	2.4	2.2	2.4
Max	3.0	2.4	3.4	7.8	2.6	2.6	3.2
Min	2.2	1.6	2.8	7.2	2.4	1.8	2.4
Hing	3.4	3.0	3.0	7.4	3.0	2.0	3.2
	2.6	2.2	3.6	7.0	2.2	2.4	3.2
	2.6	2.6	3.4	8.2	2.4	2.6	2.4
Max	3.4	3.0	3.6	8.2	3.0	2.6	3.2
Min	2.6	2.2	3.0	7.0	2.2	2.0	2.4
Garlic+hing	2.2	2.4	3.2	6.8	1.8	2.4	2.8
	2.2	1.6	2.4	7.2	2.6	1.6	3.0
	2.2	1.6	2.6	7.6	2.0	1.6	2.2
Max	2.2	2.4	2.4	7.6	2.6	2.4	3.0
Min	2.2	1.6	2.4	6.8	1.8	1.6	2.2

*There was a spray interval of two weeks from Day 28 to Day 42

Discussion

The findings illustrate the effectiveness either of plant extracts, used individually or in combination, as bio-pesticides against whiteflies and aphids. Extensive testing conducted in this study revealed that extracts from *Allium sativum* (garlic), *Piper nigrum* (black pepper), and *Ferula asafoetida* (hing) all possess pesticidal efficacy ranging from moderate to high, leading to complete eradication of whiteflies and aphids. The use of multiple plant extracts together yielded superior results compared to any single plant extract. The synergistic effect of these plants was observed to be stronger when combined than when used individually. Ali et al. (2015) found that a 50% concentration of bio-pesticides (made from Melia azedarach, Azadirachta indica, and Eucalyptus globulus) was highly effective against wheat aphids.

Furthermore, spraying mixtures such as neem oil and garlic extract, garlic extract and chili extract, garlic extract and cow urine, and neem oil combined with NSKE (neem seed kernel extract) were all effective in reducing insect and leafhopper populations on okra, as was NSKE used alone (Ali et al., 2015). The combination of neem oil (at 3% concentration) and garlic bulb extract (at 10% concentration) kept the populations of whiteflies and other insects at a minimum. Additionally, all neem components are sugar-free. Mahmood et al. (2014) found that bio-pesticides derived from Azadirachta indica, Nicotiana tabacum, and *Ferula asafoetida* were effective in reducing pest populations in okra while having negligible effects on non-target organisms and the ecosystem as a whole. According to research conducted by Bagheri and Rahimi (2014), *Ferula asafoetida* oil significantly impacted the mortality rate of dark grain insects, with just 1% of the oil required for pest control.

Variations observed may be attributed to differences in environmental conditions, elimination techniques, plant species, and regional pest populations, among other factors. In this experiment, the combination of garlic and hing proved more effective than each extract alone in reducing whitefly and insect populations, suggesting that the combined effect of both plants is stronger than either individually.

Conclusion

The study examined the effectiveness of biopesticides, which are organically produced molecules, as a safer alternative to chemical pesticides in combating plant pests and diseases. The process of creating biopesticides from plants and plant extracts is relatively inexpensive. Garlic and Hing extracts were found to be effective against certain insect pests in this study. Leaves treated with garlic and Hing bio-compounds had the lowest numbers of insect pests, including whiteflies and aphids, compared to control plots, which had the highest infestation rates of these pests per leaf. These plant-based remedies can be used either alone or in combination with other plants to enhance their insecticidal effectiveness against whiteflies and aphids in okra and potato crops, respectively.

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